

Natural Adhesive Systems

Researchers at the INEEL are defining natural adhesive systems at the molecular scale and are exploring ways to recombine proteins to improve adhesives. Such new adhesives may more strongly bond to a wide range of materials and do so in an environmentally friendly and safe manner.



Marine mussels, like *Mytilus edulis*, attach to a variety of surfaces in an aqueous environment using a natural adhesive that is incredibly strong and durable. The properties of this adhesive exceed those of conventional adhesive glues in both strength and environmental acceptability. Research shows that one of the proteins in the adhesive, *Mytilus edulis* foot protein 1 (Mefp-1), bonds to glass, plastic, wood, concrete, and Teflon. Mimicking this bonding capability would yield important, innovative adhesives for such different applications as building and construction, dentistry, surgery, orthopaedics, ophthalmology, electronics, plastics, and wood composites. A research objective is to develop a biomimetic glue that is

environmentally safer, stronger, and less expensive than currently available adhesives.

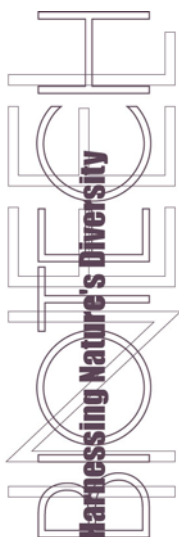
We have identified at least nine different, unique proteins in the formation of the byssus (the adhesive structure formed by the mussel). The precise mechanism for assembling the nine proteins, however, is not understood. And additional proteins may be involved in the formation of the adhesive that have not been identified. Individual protein components have been identified from byssal structures by isolating and analyzing the protein and amino acid, which reveals repetitive amino acid motifs and modified amino acids with unique characteristics not found in other biological systems. Proposed mechanisms for the strength and water-proof properties of the adhesive formed relate to these recurring amino acid motifs and the hydroxylated amino acids found in many of the protein

components. Commercial recombinant products consisting of either the partial amino acid sequence of Mefp-1 or repeats of the unique decapeptide motif are currently marketed. However, no commercial product incorporates any of the other proteins known to be involved in underwater adhesion by the *Mytilus edulis* mussel.

Research Focus and Progress

A challenge to further understanding this unique adhesive system is the unavailability of individual protein components. About 10,000 mussels are needed to produce 1 gram of adhesive from byssal structures of the animals. Collecting experimental material from these animals is not practical. Therefore, we have cloned genes into bacteria (a protein/adhesive expression system) for mass production of this natural adhesive material. This will provide sufficient adhesive materials for conventional testing. We have cloned six genes into an expression system,





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and we have initiated small-scale expression and isolation of the individual recombinant proteins. Large-scale expression of the recombinant proteins has also begun. Adhesive testing and formulation will require

additional gene cloning and insertion into the expression system. In the long range, we want to understand the underwater adhesion mechanism of the mussel by identifying the individual protein structures.



Selected Publications/Presentations

H. G. Silverman, "Identification of Adhesive Protein Clones in the Edible Blue Mussel *Mytilus edulis*," *American Society for Microbiology, Rocky Mountain Region, Idaho Falls, Idaho, April 1998.*

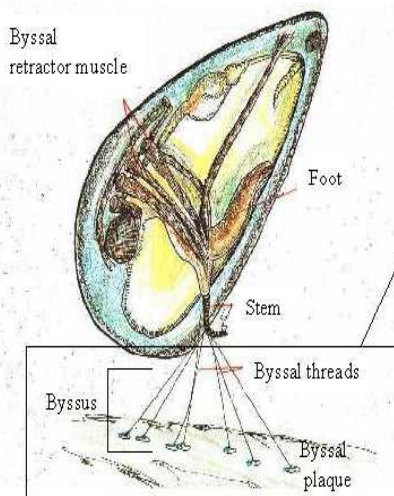
E. Y. Nicol Narus, "Cloning and Expression of *Mytilus edulis* Adhesive Proteins Using cDNA Libraries," *INEEL University Research Consortia Annual Conference, Idaho Falls, Idaho, July 1997.*

F. F. Roberto, "DOE/STP Bioadhesives Project Review," *USSOCOM, McDill Air Force Base, Florida, May 8, 1996.*

F. F. Roberto, "Bioadhesives for Underwater Applications," *OPNAV515, The Pentagon, August 11, 1994.*

F. F. Roberto, "Bioadhesives Project," *U.S. Department of Energy Special Technologies Program Expo '93, Oak Ridge, Tennessee, May 3, 1993.*

Adapted from Waite, J. H., 1991, *Chem. Ind.*, p. 607



Adapted from Waite, J. H., 1986, *J. Comp. Physiol. [B]*, p. 451

